Annual
Report of Progress
To Date

Intermodule Connector Technology for Mobile Offshore Base Structures

UNCLASSIFIED

Reporting Period: May 1997 Through September 1997

Submitted By:

Department of Mechanical Engineering
University of Maine
219 Boardman Hall
Orono, ME 04469
207-581-2120

19971021 234

A. Summary

The objectives for the work under this grant continue to be:

1. Determination of design requirements for Mobile Offshore Base (MOB) connectors and development of accurate, reliable predictions of connector performance;
2. Further development of concepts for flexible intermodule connectors and evaluation using computational modeling; and
3. Proof of concept for selected configurations through fabrication and scale model testing of most promising connector concepts

Figure 1 depicts the tasks identified for work during Phase I. To date, work has been performed under all tasks.
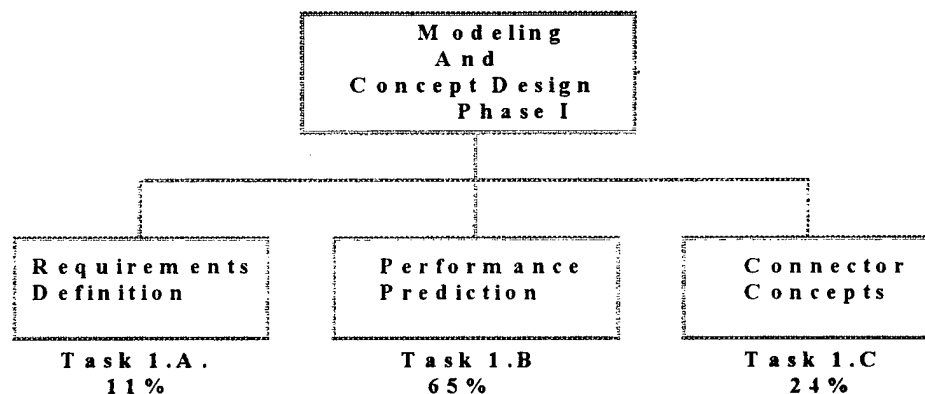
```
                    ┌─────────────────────┐
                    │     Modeling        │
                    │       And           │
                    │  Concept Design     │
                    │      Phase I        │
                    └─────────────────────┘
            ┌───────────────┼───────────────┐
   ┌──────────────┐  ┌──────────────┐  ┌──────────────┐
   │ Requirements │  │ Performance  │  │  Connector   │
   │  Definition  │  │  Prediction  │  │   Concepts   │
   └──────────────┘  └──────────────┘  └──────────────┘
     Task 1.A.         Task 1.B          Task 1.C
       11%               65%               24%
```

Figure 1

B. Accomplishments

Accomplishments to date have been focused in the areas of structural modeling, performance prediction, and intermodule connector concepts for MOBs. A brief summary of the more significant achievements is provided as follows.

As the MOB program moves through Science and Technology, it is probable that participants will bring forward several concepts for MOBs and the associated connectors. It will be necessary to evaluate the relative merits of each in a systematic, quantitative, and cost effective manner. The research is organized in phases to produce a fully validated computational and experimental structural performance prediction technique for MOB connectors.

A computational technique has been developed for prediction of the forces in and deformations of MOB connectors and associated primary structure subjected to loading caused by wind, ocean waves and currents. The technique is based upon nonlinear Finite Element Method (FEM) analysis, employing the ABAQUS™ software. The forcing function definition is sufficiently general to permit extensions that may be necessary to describe scale and transient effects, and fluid-structure interaction. Based upon specification of MOB naval architectural

parameters and representative sea states, this technique provides both absolute and comparative performance time histories of forces, displacements, positions. stress, and other parameters, for various connector configurations. The technique is based upon direct integration dynamics, with geometric nonlinearities included, permitting the physical orientation and immersion of the model to change in time. Geometric nonlinearity is required to account for the varying hydrodynamic forces due to changing immersion as the ocean waves impinge upon and propagate past the structure. Hydrodynamic loading is applied using Morison's equation. At present, the ocean model is based upon Airy wave theory.

The approach is based upon commercially available software so that development, modification, and study of various MOB and connector configurations is very rapid and highly cost effective. The simulation runs on a high end commercial computer work station. The technique includes rigid body motion of the MOB modules or, if desired, full structural response for each module. Geometric and material nonlinearities are modeled, and three dimensional effects are included so that varying wave incidence angles may be studied.

Results from applying this technique were compared with data from 1/60th MOB scale model tests conducted at the Naval Surface Weapons Center, Carderock. The application employed between 14 and 25 amplitude/frequency pairs to describe the incoming wave field. This approach provided very good agreement. However it involves significant idealizations of complex flow processes that cannot be individually assessed by scale model tests of a complete MOB.

The scientific approach for scaling the 1/60th scale model structural test data has been studied. Appropriate scaling laws have been developed for application to both static and dynamic loading. This study was in basic agreement with scaling performed at NSWC, Carderock, following the 1/60th scale model tests. It was concluded, however, that future MOB model tests should be carefully designed to include appropriate scaling science so that structural data can be appropriately scaled up to full scale MOB designs.

A number of concepts for MOB connectors have been developed and evaluated under this grant. These concepts have been based upon the four principles of flexibility, modularity, nonlinearity, and distribution. These principles were developed in order to minimize the connector loads transferred to the primary structure of the MOB modules. The results continue to indicate that flexibility is key in reducing connector loads.

Enclosure (2) includes a summary of progress to date presented at the September 24 meeting at the University of Maine.

C. Plans For Next Period

The University of Maine envisions a continuation of the work outlined above in a program with the general objective of developing and demonstrating MOB intermodule connector technology which meets specific performance requirements and is shown to be reliable, operable, and cost effective.

Future areas of investigation involve the primary determining factors for the structural response (including connector forces and deflections) of a MOB in a seaway. These two factors are the description of the floating structure (structural mass and stiffness and fluid added mass), which determines the fundamental modes of vibration and natural frequencies, and the incoming wave field, which determines the forcing function. The present analysis technique employs Airy

wave theory in an uncoupled approach to define the forcing function. Idealizations such as constant added mass and drag coefficients and an incoming wave field that is locally unaffected by the MOB dynamics will be investigated by separate effects modeling, with experimental validation . These separate effects studies will focus on simple structures built from cylinders. Results of these investigations will support the idealizations made earlier or provide the basis for an enhanced forcing function definition. Separate effects studies will also be conducted to investigate connector force scaling assumptions. Computational results for a pair of connected modules at two different scales will be compared with test data. The objective for these areas of investigation is to produce a computational technique for connector design that is validated by separate effects tests, and scale model tests of a complete MOB platform.

A separate study will be conducted in order to determine the potential beneficial effects on connector loads from integration of a dynamic position keeping controller with connector load cell sensors. Using this approach, reduction of dynamic connector loads may be feasible through application of thruster forces.

D. Concerns, Problems, Issues

None to report at this time.